FUT-K Team Description Paper 2016

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Abstract. This paper describes the long kick motion followed walking without pause after approaching the ball and the defense strategy to stop a point lost for agents of FUT-K in the simulation league of RoboCup 3D Soccer. Here, it is mentioned on a quick kick motion over a long distance obtained using a method of Covariance Matrix Adaptation Evolution Strategy, and also a prediction of the ball motion from the long kick by the opposition in order to stop the goal.

Key words: Quick kick motion, Interception for long pass, Trajectory of ball

1 Introduction

FUT-K that is mainly composed of undergraduate students of Fukui University of Technology in Japan has been organized since fall 2007. At the beginning of inauguration, we have participated in two leagues, namely one is RoboCup Soccer 3D Simulation, and another RoboCup Soccer Mixed Reality. Since the mixed reality league was withdrawn, we are concentrating operations on 3D simulation league at present.

The purposes of our team are to grow knowledge and experience of the computer language and the information science through applying themselves to RoboCup Soccer. Though almost members of our team are unskilled at programming yet, we believe that now our team is developing with getting advice from other teams.

We made seven appearances in the world competition from RoboCup 2009 in Graz to RoboCup 2015 in Hefei, and could get to a lot of things about soccer strategies and techniques of the movements for humanoid robot as the 3D soccer agent from these competitions.

In this paper, we introduce our activities for developing the 3D soccer agent of this year as follows:

- Development of kick motion over the long distance without pause after approaching the ball,
- Development of defense from the opposition agent which received a long pass,
- Prediction on the motion of a ball on the opposition agent's long kick.

The details are explained in the following sections.

2 Creation of kick motion without pause over the long distance

Since previous our TDP, namely FUT-K Team Description Paper 2015 in Hefei, has been developed on the kick motion with quick, stable and no pause after approaching the ball[1]. But, the carry of the ball in the created kick motion has become short as the compensation of such quick and stable kick motion. Now, we attempted to create a new kick motion with not only quick and stable but also flying the ball over the long distance. The created kick motion is imposed the following rules in order to make the kick motion of the agent like persons approaching the ball and kicking:

1. Before kicking at the ball, the agent does not stop with feet together just front of the ball,
2. It is not reversed until the agent finishes kicking the ball.

By using Covariance Matrix Adaptation Evolution Strategy (CMA-ES) method for parameter search needed on a kick form, we make a quick motion until the agent finishes the kicking the ball without falling down from being put in the place which is separated 1.5m from the ball. CMA-ES is the optimization algorithm which applies a dispersion covariance line to an evolution strategy.

The the evaluation function E is defined as follows:

$$E = \frac{1}{n}\sum_{i}^{n} fit_{LocX\ i} , \tag{1}$$

where fit_{LocX} is given by

$$fit_{LocX} = \begin{cases} \text{Carry of the ball along X} - \text{axis} & \text{for success} , \\ -1 & \text{otherwise} . \end{cases} \tag{2}$$

In case of success, the agent raises one leg and the ball flies to the front, and the fitness value is -1, otherwise. The X-Location of the ball, not the distance of the ball, is used because we want the agent to shoot the ball in the direction of forward, exactly. For previous our works, the evaluation function was obtained by once of try by movement generation of a long kick. But the function in this work is evaluated by averaging of 3 times of try because of adding the movement for approach to a ball.

By taking 200 as the population size and putting $n = 3$ in Eq. (1), the average and the maximum change performed repeatedly 390 times for 60 parameters in this movement is shown on Fig. 1, and the obtained results are listed in Table 1. At 390 times, the maximum of the evaluation value becomes about 16m. The kick movement with the maximum of evaluation about 16m was small compared with our long kick, but we were able to generate the movement with quick and stable.

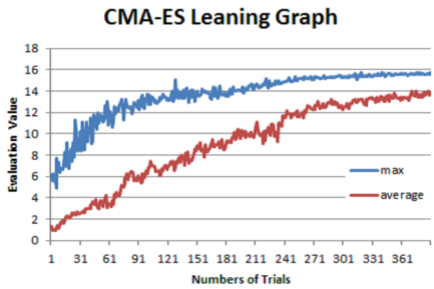

Fig. 1. The result of quick kick motion over the long distance by CMA-ES method.

Table 1. The results of a quick kick motion compared with our long kick motion. The time is until the kicking the ball by the agent which is put on the position 1m away from the ball.

	Quick kick		Long kick	
	Time [s]	Distance [m]	Time [s]	Distance [m]
1st try	3.34	11.20	5.62	17.74
2nd try	4.14	10.22	4.62	18.38
3rd try	4.28	10.28	4.80	11.84
4th try	3.96	13.07	5.22	18.51
5th try	3.96	10.66	4.42	15.16
Average	3.94	11.89	4.94	16.33

3 Defense on foe-agent received long pass

For last Robcup competition, many teams in 3D simulation league have carried out the long pass from their own ground to a friendly agent in the foe area and were making scoring chance. On analyses of point lost in our team, this pattern was most. We try to implement an algorithm of the identification on foe-agents received the long pass in oder to hamper scoring chances.

In generally, foe-agents received the long pass would exist near our team's goal in its own area. So, the position of foe-agents close from our team's goal is checked to presume the foe-agent in our area which is seemed to receive the long pass. In order to estimate the position of foe-agents in the place close from our team's goal, we define an orthogonal coordinate system shown in Fig. 2. The coordinate with the center of the center circle as the origin has negative value of x coordinate for our area in the soccer field and is $x = -15$ at our goal mouth, where our area is taken as the left side in the field.

By using new coordinate system, it is sorted for x value of foe-agents existing in our area in descending order, and the foe-agent with the closest distance from our team's goal and a foe-agent near the 2nd distance are selected as candidates received the long pass.

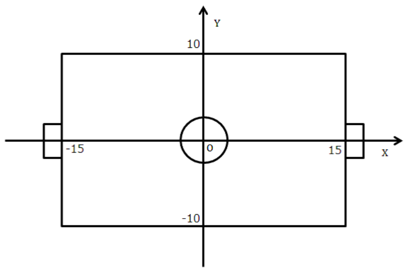

Fig. 2. An orthogonal coordinate system is defined in the field in order to determine the position of foe-agents in the place close from our team's goal. The new orthogonal system has the center of the center circle as the origin and has negative value of x coordinate for our area in the soccer field and is $x = -15$ at our goal mouth, where our area is taken as the left side in the field.

We have a case of the difference

$$|\ell_i - \ell_{i+1}| \leq d \ , \tag{3}$$

where ℓ_i and ℓ_{i+1} are distances of i-th and $i+1$-th foe-agents in the place close from our team's goal, respectively. d means the minimum distance between foe-agents and is put as 2.5m. If there exists more than 2 foe-agents within the 2.5m, then the foe-agent with the far distance is removed because only our one agent can probably check both foe-agents when the distance between foe-agents is close.

Next, we discuss on a way of information sharing for friendly-agents. In order to get information on positions of all foe-agents in our area received the long pass, friendly-agents always look for foe-agents. By using "Say"-message token, it decide to renew information on the foe-agent with the closest distance from our team's goal and a foe-agent near the 2nd distance. For marking 2 foe-agents with the closest and 2nd distances, we move 4 friendly-agents F_1, F_2, F_3, and F_4 to any positions as follows:

$$F_1(R_{1x} + \delta x, R_{1y} + \delta y) \ , \qquad F_2(R_{2x} + \delta x, R_{1y} + \delta y) \ ,$$
$$F_3(R_{1x} + \delta x, R_{2y} + \delta y) \ , \qquad F_4(R_{2x} + \delta x, R_{2y} + \delta y) \ ,$$

where positions of 2 foe-agents are put as (R_{1x}, R_{1y}) and (R_{2x}, R_{2y}), respectively. δx and δy represent gap distances to the foe-agent.

4 Prediction on motion of ball

By marking foe-agents in our area received the long pass by friendly-agents, even if the point lost from a long pass can be stopped, the point lost from a long kick in foe area cannot be stopped in our team. So, it try to expect a movement of a ball in the long kick flying over the air, and our goalkeeper attempts to block its ball. For predictions on the movement of the ball kicked by the agent, there are no cases that the ball bends in the air, the movement of the ball is only considered at two dimensions of a direction of movement of a ball and the height.

Let us define x and z-axis as the a direction of movement of a ball and the height, and assume . that the ball has no spin while moving through the air[2]. Then, the movement equations are described at any time $i + 1$ as

$$\ddot{x}_{i+1} = -k\dot{x}_i \ , \tag{4}$$

$$\ddot{z}_{i+1} = -k\dot{z}_i - \gamma \ g \ , \tag{5}$$

where k and g mean a proportionality coefficient of the drag force and a magnitude of gravitational acceleration, respectively. γ is a correct parameter. It was not taken into account Magnus force because of the ball with no spins.

For the bound of the ball with the ground, the movement of the ball is given as

$$\dot{x}_{i+1} = \dot{x}_i \ , \tag{6}$$

$$\dot{z}_{i+1} = -e \ \dot{z}_i \ . \tag{7}$$

Here e is a coefficient of restitution, and $\dot{x}_i(\dot{z}_i)$ and $\dot{x}_{i+1}(\dot{z}_{i+1})$ the magnitude of the velocity before the bound and after one, respectively.

From Eqs. (4) – (7), we can estimate the position and the velocity of the ball at any time i by adding the states from the initial state $i = 0$ at which the ball was kicked. It shows the result on our estimation of the movement of the ball on orange dots with real carrying the ball on light green dots in Fig. 3. We can mostly calculate the trajectory of the ball by choosing the values of parameters.

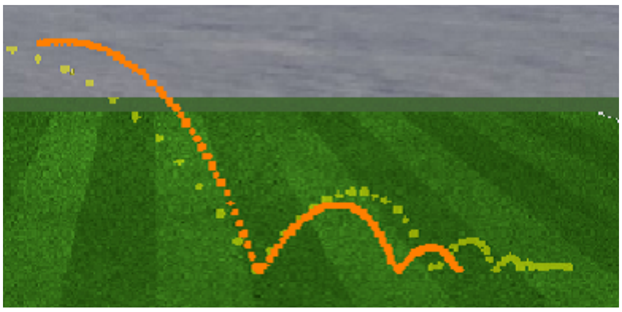

Fig. 3. The result of the prediction on the movement of the ball. The orange dots and the light green dots represent trajectories of the ball by our estimation and of the real carrying the ball, respectively.

5 Conclusions and Future Works

By creating the kick motion without pause over the long carry, our agent could kick the ball in time half of the previous long distance kick. We expect that the score rate of our team is risen because our agent with quick motion kick can put in a goalpost from the nearby distance, quickly.

We implemented the program of marking by 4 friendly-agents to 2 foe-agents received the long pass from the opposite area. As the result of practice games, friendly-agents could mark to foe-agents in our area and could intercept with long passes. However, friendly-agents were locally marked too much and the long pass was sometimes permitted, so we would like to improve the positions of friendly-agents marking to foe-agents.

For our prediction on the trajectory of the ball, the precision was good in the ball speed with fast. On the other hand, the precision became bad when it became slow in the speed of a ball. Therefore, the improvement of trajectory of the ball with low speed is needed. Also now, the goalkeeper-agent is not implemented to create motions corresponding to trajectory of the ball. In future works, we will improve the goalkeeper program in order to block the attacks from the long shot

Acknowledgements

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